OGP Progress Report

Title of Abstract: Improved Water Demand Forecasting for Water Resources Managers
Project Duration: 5/1/03-4/30/06
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Project Background

Evapotranspiration (ET) from irrigated crops and riparian vegetation, and evaporation from open-water surfaces are the primary consumers of surface water in the Western U.S. To address this issue, the U.S. Bureau of Reclamation (Reclamation) has developed and implemented the Agricultural WAter Resources Decision Support (AWARDS) system which is now operational in portions of Oklahoma, Oregon, Washington, Montana, Arizona, and New Mexico (Hartzell et al., 2000). The AWARDS system is an automated information system to assist water managers and users by providing easy access to rainfall and daily crop water use estimates. These estimates are based on real-time data obtained from the WSR-88D (Weather Surveillance Radar – 1988 Doppler) radar system and automated weather stations. Building on the AWARDS system, Reclamation has been developing an Evapotranspiration Toolbox (ET Toolbox) which adds GIS land use to specify crop, riparian, and open water surface acreage, as well as the vegetation type and coverage within selected Hydrologic Rainfall Analysis Project (HRAP) grid cells (Hartzell et al., 2002). The ET Toolbox estimates the daily surface water use requirements at a resolution useful for implementation in Upper Rio Grande Water Operations Model (URGWOM).

To further address this concern with water consumption, a team of researchers at NASA Goddard Space Flight Center have been developing the North American Land Data Assimilation System (NLDAS), which has been a multi-institutional project and has a variety of physically-based, land-surface models (LSMs) implemented in the system. For this study, the LSMs include Noah (Mitchell et al., 2000) and the Community Land Model, version 2 (CLM2; Dai et al., 2002). Recently, NLDAS was enhanced through the incorporation of the Land Information Systems (LIS) modeling framework and the LSMs are run currently at 0.01 degree (~1 km) resolution for the New Mexico region, focusing on the Upper and Middle Rio Grande Basins and the Pecos River Basin. A variety of satellite datasets are used to help parameterize and drive the models, including data from NOAA's Advanced Very High Resolution Radiometer (AVHRR) and NASA's Terra and Aqua's MOderate Resolution Imaging Spectroradiometer (MODIS) instrument. In this project, we are using satellite-derived land cover, leaf area index (LAI), and land surface temperature (LST) products, and comparing the LSM experiments to assess the sensitivity of the different models to these parameters. In addition to AVHRR and MODIS products, other satellite products, including Landsat and ASTER, are being evaluated and soon to be tested with the LSMs to better understand how and where they can improve the scaling of models' energy and water budget variables.

Project Goals

The main goal of this project is to apply NLDAS and remotely sensed products, like those of MODIS, to the AWARDS ET Toolbox. Our aim is to improve our understanding of their contributions to the daily-weekly predictability of ET, based on different vegetation types, open water evaporation, and bare soil conditions. NLDAS outputs will be compared and incorporated in to the Reclamation-developed ET Toolbox for the Middle Rio Grande area and evaluated with and without the new products. Water demand forecasting as addressed in this project is limited to the water demands from irrigated agriculture, riparian vegetation, and evaporation from open water surfaces. The study area includes the Middle Rio Grande in New Mexico from just above Cochiti Reservoir southward to Elephant Butte Dam. This project also addresses the issues involved with the resolution (spatial and temporal) of vegetation indexing needed for AWARDS and the ET Toolbox, and it examines how knowledge of the soil moisture fields from the LSMs and field observations can better estimate the ET consumptive amounts. Finally, some of the different MODIS products, like land surface temperature, will be assimilated into the LSMs to improve their ability to estimate ET and their effect on soil moisture estimates.

Method

Some of the underlying approaches for this project involve validating and benchmarking the ET of different LSMs and associated variables, parameters, and forcing which are used to calculate the ET with the current AWARDS ET-Toolbox decision support system (DSS). MODIS vegetation parameters and land cover/use products are being used to characterize the larger domain vegetation changes, and other MODIS land products, like land surface temperature, will be assimilated to update and enhance some of these LSM ET predictions. To customize the NLDAS to more appropriately represent the Rio Grande basin region, the NLDAS-LIS based modeling system will be modified by employing the highest resolution information available (e.g., soils data, land class parameters, etc.) and assimilating MODIS products at 1-km and sub 1-km resolutions. Current aspects of the AWARDS ET-Toolbox DSS, like the real-time data from WSR-88D radar and automated weather stations and the land cover information pertaining to the Land-Use Trend Analysis dataset, will be incorporated in to the modified NLDAS-LIS modeling framework.

For the validation studies, observations from a growing network of meteorological stations in and around the basin are being used for comparison with the model forcing and state variables. Two eddy covariance flux towers have been installed in the Albuquerque, New Mexico, region and will be collecting ET flux information from an agricultural field and next to the Rio Grande River. The towers are collecting also radiation fluxes, soil temperature and moisture, and precipitation. Both towers, along with the current network of stations, will be used for further validation and sensitivity case studies for this project.

Results and Accomplishments

Work Accomplished in FY04 of this investigation:

- Set up two eddy covariance flux towers in Albuquerque, New Mexico, in Reclamation and Middle Rio Grande Conservancy District areas of interest
- Downscaled the 1/8 degree NLDAS domain to a 0.01 degree (~1 km) geographic domain for the state of New Mexico. We are currently running the Noah and CLM2 LSMs where we have used a five-year spin-up, using elevation-adjusted NLDAS forcing.
- Simulations for the two LSMs have been completed up through the end of 2003 and are currently being analyzed. Different sensitivity case studies are being conducted to study the differences between the original LDAS AVHRR UMD land classification dataset and the current MODIS UMD dataset.
- Comparisons of the NLDAS forcing to Reclamation's existing in-situ and operational data (static and time-varying) – initial validation phase and benchmarking:
  - Compared 8 of the meteorological stations with the NLDAS forcing (at original 1/8 degree domain and downscaled 0.01 degree).
  - Comparing land use/cover (e.g., vegetation, soil) parameters and characteristics between NLDAS and datasets used in AWARDS ET-Toolbox
- Generated frequency tables that align the Land Use Trend Analysis (LUTA) map (used in the AWARDS ET Toolbox) with the latest MODIS land cover datasets, which will be used to parameterize the NLDAS-LIS set-up on sub-1km scales and will be used with a higher resolution, UTM projection for the LUTA region LSM runs
- Presented initial results of study at GAPP PIs meeting poster session in Boulder, CO, in September 2004
- Presented current results from the modeling sensitivity case studies and validation of the NLDAS forcing at the 2005 AMS Annual Meeting in San Diego, CA.

Future Work

Work to be accomplished within the next year includes the following:

- Run selected LSMs for over Rio Grande area with 1 km MODIS-based classifications
  - Adjust forcing datasets for the 1-km runs, starting with the merged Stage IV/gage/Eta forecasted precipitation products, to be later aggregated to the the HRAP level for comparison
  - Begin using Reclamation's radar and gage-based higher resolution products in the modified NLDAS-LIS system
- Incorporate the much finer resolution parameter (e.g., soil classes) and land class/use information (e.g., the LUTA information) into NLDAS-LIS and treat this information as sub-grid heterogeneity (e.g., like "tiles") of the 1-km resolution grid system. Then the different LSMs will be run with these datasets and validated with the in-situ measurements (e.g., soil moisture and energy fluxes).
- Quality control the EC flux tower datasets and set them up for real-time downloads and validation for the AWARD ET Toolbox
- Identify and implement optimal land assimilation techniques for assimilating MODIS LST into the Noah and CLM2 models. Assess possible improvements in ET and soil moisture with a retrospective analysis, and a near-real time analysis (using the MODIS Rapid Response LST product; available within 2-3 hour satellite after overpass).
- Complete analyses and write final report.

- Publish findings at GAPP/AMS Meetings and in relevant publications

References:

Dai, Y. et al., 2003: The Common Land Model. *Bulletin of the American Meteorological Society*, Vol. 84, No. 8, pp. 1013–1023.

Hartzell, C.L., L.A. Brower, R.W. Stodt, and S.P. Meyer, 2000: Agricultural Water Resources Decision Support System. *Preprints, 2nd Conference on Environmental Application*, Amer. Meteor. Soc., Long Beach, CA, pp. 98-105.

Hartzell, C.L., L.A. Brower, and S. Hansen, 2002: Agricultural Water Resources Decision Support System and Evapotranspiration Toolbox. *Preprints, 16th Conference on Hydrology*, Amer. Meteor. Soc., Orlando, FL, pp. J198-J203.

Mitchell, K., et al., 2000: The collaborative GCIP Land Data Assimilation (LDAS) project and supportive NCEP uncoupled land-surface model initiatives. *Proc. 15th Conference on Hydrology*, American Meteorological Society, pp. 1-4.

Publications from this project:

None at this reported time

Presentations:

Stodt, R., D. Matthews, S. Hunter, A. Pinheiro, K. Arsenault, and P. Houser, Improved water demand forecasting for water resources managers, paper presented at the 85th AMS Annual Meeting, January 2005, San Diego, CA

Stodt, R., D. Matthews, K. Arsenault, A. Pinheiro, and P. R. Houser, Improved Water Demand Forecasting for Water Resource Managers, poster presented at the GAPP PI Meeting, September 2004, Boulder, Colorado.

Pinheiro, A., K. Arsenault, P. Houser, D. Toll, S. Kumar, D. Matthews, and R. Stodt, Improved evapotranspiration estimates to aid water management practices in the Middle Rio Grande River Basin, paper presented at IGARSS Conference, September 2004, Anchorage, Alaska.

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